CS 791 - Randomized Algorithms

K. Subramani
LDCSEE,
West Virginia University,
Morgantown, WV
{ksmani@csee.wvu.edu}

1 General Information

1. Semester - Spring 2012.
2. Meeting Times: Tu-Th, 09 : 30 am -10 : 45 am.
   Location: 355 ESB-E.
3. Contact Information: 749 ESB, ksmani@csee.wvu.edu.
4. Office Hours: By appointment.
5. Prerequisites: Exposure to probability and algorithm design.
6. Textbook - [MU05] is the main text, although [MR95] and [Ros00] are strongly recommended for supplementary reading.
7. URL - http://www.csee.wvu.edu/~ksmani/courses/sp12/rand/rand.html.
8. Assessment:
   (a) Homeworks (3) - There will be three homework assignments; each assignment is worth 20% of your grade. Table (1) details the homework schedule.

Assignment Date	Submission Date
01/26	02/02
03/01	03/08
04/03	04/10

Table 1: Homework Schedule

   (b) Presentation (1) - You will be required to present one topic which will be decided through discussions with the instructor. The presentation is worth 20 points.
   (c) Research - You are expected to engage in independent research on a problem of your choosing (or a critique of existing research), related to the topics of this course. This research is to be summarized in a report, to be handed in on the last day of class and is worth 20 points. *If your research results in publishable work, then you will be assigned an* **A** *in the course, regardless of your performance on the other assignments.* Alternatively, you will be handed a fourth homework assignment, on May 1, which you will need to turn in by May 8.
   (d) Final - There will be no final exam.
   (e) A maximum of 5 bonus points will be awarded for class performance.

9. Grade Boundaries:

Grade	Boundary
A	80 and up
B	$65 - 79$
C	$50 - 64$
D	$45 - 49$
F	$0 - 44$

Table 2: Grade Boundaries

10. Grading policy - If you have any questions about the grading, you must contact the intructor within two days of your paper being returned.

11. Makeup Policy - If for some reason, you are unable to attend a test or an exam, please meet me at the earliest and I will set an alternate date.

12. **Course Objectives** - The objectives of this course are as follows:

    (a) Introducing the fundamentals of probabilistic analysis.

    (b) Analyzing algorithms in the probabilistic framework.

    (c) Introducing high probability analysis.

    (d) Introducing the Monte Carlo method.

    (e) Introducing Randomized Complexity classes.

13. **Learning Outcomes** - Upon successful completion of this course, students will be able to:

    (a) Appreciate the fundamentals of randomized algorithm design.

    (b) Develop randomized algorithms for variants of problems in `P`.

    (c) Apply high probability analysis to selected randomized algorithms.

    (d) Apply the Probabilistic Method for establishing the existence of properties in combinatorial structures.

    (e) Understand the fundamentals of Markov chains and the Monte Carlo method.

2 Syllabus Sketch and Weekly Schedule

2.1 Rudiments

2.1.1 Probability Fundamentals

Sample Space, Events, Assigning probabilities to events, Conditional probability, Independent events, Useful identities, Random Variables, Linearity of Expectation. (4 Lectures).

2.1.2 A sampling of Randomized Techniques

Verifying polynomial identities, verifying matrix multiplication, A min-cut algorithm, The coupon collector's problem, Quicksort. (1 Lecture).

The above material is covered in Chapters 1 and 2 of [MU05] and in Chapters 1 and 2 of [Ros00].

2.2 High Probability Analysis

2.2.1 Moments and Deviations

Markov's inequality, Moments of a Random Variable, Chebyshev's inequality, Applications. (2 Lectures).

2.2.2 The Chernoff Bound

Moment Generating Functions, Deriving and Applying Chernoff bounds, Special cases, Applications. (2 Lectures).

The above material is covered in Chapters 3 and 4 of [MU05].

2.3 Advanced Analysis

2.3.1 Balls and Bins

The Birthday Paradox, Balls into Bins, The Poisson Distribution, The Poisson Approximation, Applications.

2.3.2 The Probabilistic Method

The basic counting argument, The Expectation argument, Derandomization using conditional expectation, Sample and Modify, The Second Moment method, The Conditional Expectation Inequality, The Lovasz Local Lemma, Explicit Constructions using the Local Lemma, The general case of the Local Lemma. (2 Lectures).

2.3.3 Markov Chains and Random Walks

Definitions and Representations, Classification of states, Stationary distributions, Random walks on undirected graphs, Parrondo's paradox. (2 Lectures).

The above material is covered in Chapters 5, 6 and 7 of [MU05].

2.4 Advanced Applications

2.4.1 The Monte Carlo Method

The Monte Carlo Methods, The DNF counting problem, From Approximate sampling to Approximate counting, The Markov Chain Monte Carlo Method. (2 Lectures).

2.4.2 Martingales

Martingales, Stopping Times, Wald's Equation, Tail Inequalities for Martingales, Applications. (2 Lectures).

The above material is covered in Chapters 10 and 12 of [MU05].

I would like to reiterate that this is a sketch of the topics that we will be covering. For various reasons, I may choose to drop a mentioned topic or cover a new topic. In such cases, advance notice will be given.

3 Social Justice Statement

West Virginia University is committed to social justice. I concur with that commitment and expect to foster a nurturing learning environement, based upon open communication, mutual respect and non-discrimination. Our University does not discriminate on the basis of race, sex, age, disability, veteran status, religon, sexual orientation, color or national origin. Any suggestions to further such a positive and open environment in this class will be appreciated and given serious consideration. If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me of the same and make appropriate arrangments with Disability Services $(293 - 6700)$.

If you feel that you are being treated inappropriately or unfairly in any way, please feel free to bring your concerns to my attention; rest assured that doing so will not prejudice the grading process. In return, I expect you to behave professionally and ethically.

References

[MR95] Rajeev Motwani and Prabhakar Raghavan. *Randomized Algorithms*. Cambridge University Press, Cambridge, England, June 1995.

[MU05] Michael Mitzenmacher and Eli Upfal. *Probability and Computing*. Cambridge University Press, 1^{st} edition, 2005.

[Ros00] Sheldon M. Ross. *Probability Models*. Academic Press, Inc., 7th edition, 2000.